EXECUTIVE SUMMARY

PHASE I. Objective: To determine lead levels in free-ranging eagles in east central Idaho.

Work performed/results: Data were collected on eagles trapped from winter 1989-90 through winter 1996-97. Although we concentrated our trapping efforts primarily in the Lemhi and Pahsimeroi River Valleys, we also trapped birds in the Birch Creek Valley during winter 1996-97 because of historical accounts of lead contamination in that area (Oberg 1970). In addition, we collected a few blood samples from injured eagles that were turned in to the Idaho Department of Fish and Game during the course of the study.

In all, data were collected from 297 wintering golden eagles. Blood samples were analyzed for 290 of these birds. We also collected data from 39 wintering bald eagles and took blood samples from 36 of these birds.

Most (99.6%) golden eagles and 100% of the bald eagles sampled had detectable levels of lead in their blood (minimum detection limit: 0.01 ppm). Elevated blood lead levels ($\geq$ 0.20 ppm; Kramer and Redig 1997) were found in 45.6% of the wintering golden eagles and 61.1% of the bald eagles. There was no significant difference between the blood lead levels of golden eagles in the two major river drainages within the study area.

Although the number of golden eagles captured in the Birch Creek Valley (n=5) was too small for statistical analysis, lead levels in these birds are similar to those in the other two valleys. All of the birds sampled in Birch Creek had detectable levels of lead in the blood and two of the five (40%) had blood lead levels elevated above background.

Biologically incorporated lead (lead that has been ingested by prey animals and then incorporated in their tissues) is not thought to be a pathway of lead to raptors, at least, at higher levels of exposure (Pattee and Hennes 1983). Kramer and Redig (1997) and Pattee et al. (1990) found the highest incidence of lead contamination in eagles during the winter months and suggested that lead bullets, embedded in unretrieved game during hunting seasons, were the source of elevated lead levels in eagles. Nonetheless, because east central Idaho is an historic lead mining area in which lead contamination was a serious problem in the late 1800s, we could not ignore the possibility that lead contamination in eagles resulted from sources other than ingested shot or bullets.

PHASE II. Objective: To determine the source of lead contamination.

Work performed/results: We collected blood samples from 12 nestling golden eagles, just prior to fledging, in the Lemhi and Pahsimeroi Valleys in 1991 and 1992. No lead contamination was detected in these birds. Therefore, we concluded that the prey fed

these eaglets and which came from within their parents' home ranges, were not contaminated with lead.

Black tailed jackrabbits (*Lepus californicus*) are a major prey of eagles wintering in our study area (pers. observ.). To determine if biologically incorporated lead in the tissues of these prey was an avenue of lead to eagles, we collected jackrabbits in the winter of 1993-1994. Liver and muscle tissue samples were collected from jackrabbits in the Lemhi (n = 32) and Pahsimeroi (n = 29) Valleys, respectively. All of the liver samples were analyzed for lead but only muscle samples from jackrabbits with liver lead levels $\geq$ 0.50 ppm were analyzed. Most, (72.1%) of the jackrabbits sampled had liver lead levels below the detection limit and those with detectable lead in tissues had low levels. Research by Hoffman et al. (1981) on bald eagles suggests that the lead levels in jackrabbit tissues sampled in our study area are not high enough to elevate eagle blood lead levels above the detection limit.

In the winter of 1995-96 we fitted 6 golden eagles with satellite-monitored radio-transmitters, or Platform Transmitting Terminals (PTT). The satellite technology allowed us to obtain data on movements of the eagles across mountain ranges, as well as their migration patterns and year-round use areas. All 6 of the eagles we monitored had elevated blood lead levels. Tracking via satellite was continued for the life of the PTT battery, until the radio failed, or until the eagle was recaptured and the radio was removed.

The objectives of this tracking effort were to determine:

- if golden eagles with elevated blood lead levels were migrants or year round residents in our study area;
- the extent of interchange of golden eagles between the Lemhi and Pahsimeroi Valleys;
- the migration routes and summer and winter ranges of golden eagles with elevated blood lead levels;
- if there are common patterns of movements in golden eagles with elevated blood lead levels.

One of the 6 eagles we studied was a long-distance migrant whose radio failed in the spring following capture. This eagle was last located in April 1996 in central British Columbia, Canada. In contrast, another of our radio-tagged eagles was a year-round resident in the Lemhi Valley. The other four birds were "regional residents", ranging across portions of eastern Idaho and western Montana.

Interestingly, the only area used in common by all of these eagles was their winter range in our study area. It has been shown that golden eagles show annual fidelity to wintering and nesting areas (current study, Marzluff et. al. 1997, Brodeur et al. 1996). Therefore, it is probable that the eagles we studied made the same annual movements before and after we fitted them with PTT's. Consequently, these 6 eagles were probably all exposed to lead within the annual ranges we have identified for them.

Furthermore, the eagle that remained in our study area year-round was likely exposed to lead within the Upper Lemhi Valley. In addition, the four eagles that were "regional residents" probably were exposed to lead in or near (within several hundred kilometers) our study area. The eagle that was a long-range migrant may have been exposed to lead anywhere on its winter range in Idaho, on its summer range, or along its migration route into Canada.

Management Implications for Phase I and II.

The telemetry data we collected showed that the annual ranges of the 6 golden eagles studied, include BLM administered lands throughout east central and southern Idaho, and Montana. Further, this study demonstrated that the golden eagle population in the study area comprises resident nesters, regional residents, and long distance migrants. If we assume that the movements of these birds after we began monitoring them were similar to their movements in the past, we can conclude that some contamination likely occurred locally. We do not know the specific source(s) of lead contamination in our study area. However, the area is used regularly by both species of eagles and many of them are contaminated with lead.

Most of the lead levels we found in eagles were sublethal. However, the specific effects on eagles of long-term, low-level exposure to lead are unknown. Approximately half of the eagles sampled were exposed to lead and our recapture data indicate that this exposure may be chronic. Further research is needed on the impact this chronic exposure may have on eagle populations over time.

INTRODUCTION

Lead contamination has been reported in free ranging bald and golden eagles, sometimes in quantities that can cause mortality (Kramer and Redig 1997, Pattee et al. 1990, Reichel et al. 1984, Kaiser et al. 1980). Other researchers also have identified lead poisoning as a threat to raptors (Platt 1976, Hoffman et al. 1981, Pattee and Hennes 1983, USF&WS 1985, Wiemeyer et al. 1989, Nelson et al. 1989, Pattee et al. 1990). Similarly, it has been suggested that long-term, low-level exposure to lead may weaken birds and affect reproduction, predispose birds to injury from environmental hazards or cause increases in predation, starvation and disease (Kramer and Redig 1997, Task Group on Metal Accumulation 1973, Pattee et al. 1981, Kendall 1982). Unfortunately, the effects of sublethal exposure to wildlife populations have been little studied (Pattee et al. 1981, Kendall 1982, Eisler 1988).

We began investigating lead (Pb) contamination of eagles in Idaho during winter 1989-90 after finding incidents of Pb poisoning in bald and golden eagles in Idaho from 1977 through 1986 (Craig et al. 1990). The eagles reported in that study were all dead or moribund birds that had been turned in to the Idaho Department of Fish and Game from throughout the state. Five of 16 golden eagles and five of 6 bald eagles reported in that study were confirmed by the National Wildlife Health Research Center in Madison, Wisconsin to have died of lead poisoning. In addition, 83% of the bald eagles and 44% of the golden eagles had elevated concentrations of lead in their livers (Craig et al. 1990).

Data presented herein are the results of a subsequent eight-year study of lead and mercury levels in free-ranging golden eagles (*Aquila chrysaetos*), and bald eagles (*Haliaeetus leucocephalus*) that winter in east central Idaho. This research was divided into two different phases. Phase I of the study was to determine the extent of lead contamination in free ranging eagles that winter in east central Idaho. During this part of the study, we also monitored changes in blood lead levels in the sample eagle population, as well as, blood lead levels of individual eagles through time. Phase II of the study was to determine if the source of lead contamination to the wintering eagles in our study area originated locally. During this phase of the study, we sampled blood lead levels of nestling golden eagles and lead levels in tissues of eagle prey in the study area. We also monitored the movements of 6 golden eagles with elevated blood lead levels using radio telemetry via satellite from 1996-1997. The telemetry data allowed us to determine:

- if golden eagles with elevated blood lead levels are migrants or year round residents in our study area;
- the extent that individual golden eagles move between the Lemhi and Pahsimeroi Valleys;
- the migration routes and summer and winter ranges of golden eagles with elevated blood lead levels;
- if there are common patterns of movements in golden eagles with elevated blood lead levels.

STUDY AREA

We trapped wintering golden and bald eagles within the adjacent Lemhi and Pahsimeroi River Valleys, parts of the Birch Creek Valley and nearby portions of the Salmon River Valley in Lemhi and Custer Counties, Idaho (Figure 1). The study area is bounded on the north by the Salmon River, the east by the Continental Divide and the west by the Lost River Mountain Range. The Lemhi mountains, which rise to over 3600 m, separate the Lemhi Valley from the Pahsimeroi Valley. Both valleys range in elevation from approximately 1250 m to 2200 m and are each about 120 km in length. A hydrologic divide separates Birch Creek, which flows to the south, and the Lemhi River, which flows to the north.

The native habitat in the valleys and nearby foothills is typical of cool desert vegetation (Odum 1971). It is dominated by big sagebrush (*Artemisia tridentata)*-grass associations. This vegetation is interrupted in riparian areas by willow, *Salix* spp., birch, *Betula* spp. and cottonwood, *Populus* spp. Hay fields and irrigated pasturelands occur along the rivers and creeks, especially at lower elevations. Habitat in the mountains is mostly coniferous forests: predominantly Douglas fir, *Pseudotsuga menziesii*, and lodgepole pine, *Pinus contorta*. Rocky, snow-covered peaks occur above timberline.

Eagles that were radio-tagged in the study area and then tracked via satellite, ranged over parts of Idaho, Montana and British Columbia, Canada during the year after capture.

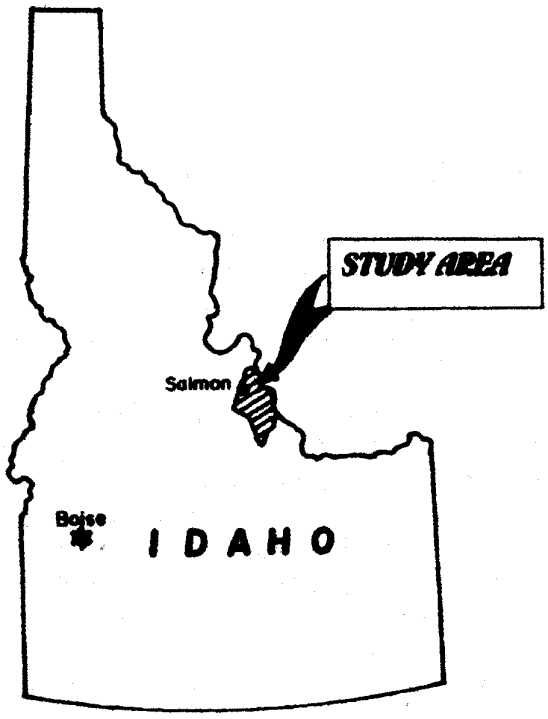

Figure 1. Location of the winter study area for the eagle project in east central Idaho; 1990 through 1997.

SECTION I. AN EIGHT-YEAR STUDY OF BLOOD LEAD AND MERCURY LEVELS IN WINTERING GOLDEN AND BALD EAGLES IN EAST CENTRAL IDAHO; 1990-1997.

METHODS

CAPTURE AND PROCESSING OF EAGLES

Wintering eagles were captured with padded leg-hold traps (after Bloom 1987), or occasionally, by hand. Samples also were collected from injured birds obtained from the Salmon Region of the Idaho Department of Fish and Game. Nestling eagles were captured just prior to fledging.

Captured birds were banded, measured (footpad, wing chord, tarsus, hallux, culmen and cranium) and photographed. Most birds were banded with white or silver USF&WS bands on one leg and a numbered or alpha-numeric colored band (orange, yellow, or green) on the other. Five cc blood samples were collected by brachial vein puncture and then were placed in heparinized glass tubes and frozen at the end of each day.

BLOOD SAMPLE ANALYSIS

Lead analysis of blood samples was done at the Holm Research Center at the University of Idaho in Moscow, Idaho for 6 of the 7 winters of the study. Analysis at the Holm Research Center was done with a Perkin-Elmer Zeeman 5011 PC Atomic Adsorption Spectrophotometer graphite furnace at a wavelength of 283.3 nm.

Lockheed Martin, a Lockheed Idaho Technologies Company in Idaho Falls, Idaho analyzed all golden eagle blood samples collected during winter 1995-96. In order to place PTT's on eagles with elevated blood lead levels and still release them quickly, it was necessary to analyze blood samples on the same day eagles were captured. Lockheed Martin is the closest facility capable of the lead analysis we required. They determined lead levels with a VG Elemental PlasmaQuad through inductively coupled plasma-mass spectroscopy (ICP-MS). A wavelength of 207.97 nm was used for lead, and an internal standard of indium was used at a wavelength of 114.9 nm. The lower limit of reportable residues was 0.01 ppm (wet weight) for lead in all samples.

Golden eagle blood samples were analyzed for Hg levels through the winter of 1994-95. Bald eagle bloods were analyzed for Hg every year of the study. Total mercury was analyzed by ICP atomic emission in a hydrogen-saturated atmosphere on the Perkin-Elmer P-40 or Leeman 2000. The lower limit of reportable residues was 0.001 ppm (wet weight) for Hg.

DATA ANALYSIS

All eagles were classified as either: subadult female, subadult male, adult female and adult male for statistical analysis. We did not take a second blood sample from eagles recaptured within five days of first capture. However, calculations of age and sex ratios were based on all birds captured, including these short-term recaptures. Therefore, the sample sizes for age and sex ratios are larger than those used in analysis of blood lead data. In addition, data from recaptured birds were not used in ANOVA tests because the samples were not necessarily independent of one another.

Blood lead values in eagles were sorted into four categories for analysis: <0.20 ppm = background; 0.20 ppm - 0.60 ppm = exposed; 0.61 - 1.20 = clinically affected; >1.20 ppm = acute lead poisoning (Kramer and Redig 1997).

For statistical tests requiring lead concentration data that are normally distributed, values were multiplied by 1000 and then log-transformed prior to analysis. Samples with lead values below detection were analyzed using one-half the minimum detection level (after Pattee et al. 1990). All means reported in the data are arithmetic means unless otherwise stated. The winter golden eagle blood lead data for the Pahsimeroi and Lemhi Valleys were examined using a two (valleys) by two (sexes) by 7(years)